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CORRES. CONTROL
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DOE ORDER# 4700.1

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DIST.	LTR	ENC
AMARAL, M.E.		
BURLINGAME, A.H.	X	
BUSBY, W.S.		
BRANCH, D.B.		
CARNIVAL, G.J.		
DAVIS, J.G.		
FERRERA, D.W.		
FRAY, R.E.		
GEIS, J.A.		
GLOVER, W.S.		
GOLAN, P.M.		
HANNI, B.J.		
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HEDAHL, T.		
HILBIG, J.G.		
HUTCHINS, N.M.		
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MARX, G.E.		
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MONTROSE, J.K.		
MORGAN, R.V.		
POTTER, G.L.		
PIZZUTO, V.M.		
RISING, T.L.		
SANDLIN, N.B.		
SCHWARTZ, J.K.		
SETLOCK, G.H.		
STEWART, D.L.		
STIGER, S.G.	X	
TOBIN, P.M.		
VOORHEIS, G.M.		
WILSON, J.M.		
Chromec FW	X	X
Hopkins JK	X	X
Roberts RS	X	X
CORRES. CONTROL	X	X
ADMN RECORD/080	X	(2)
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FWC: FWC

ORIG & TYPIST INITIALS
FWC: kld

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September 22, 1994 94-RF-09791

Jessie M. Roberson
Acting Assistant Manager for
Environmental Restoration
DOE, RFFO

Attn: N. I. Castaneda

RESPONSE TO COMMENTS ON THE PROGRAMMATIC RISK-BASED PRELIMINARY REMEDIATION GOALS - SGS-518-94

Action: Review Response As Soon As Possible

EG&G Rocky Flats has reviewed the Environmental Protection Agency (EPA) and Colorado Department of Public Health & Environment (CDPHE) comments on the Programmatic Risk-Based Preliminary Remediation Goals as requested by the Department of Energy, Rocky Flats Field Office (DOE, RFFO) and prepared the attached response.

As noted in our response, we concur with the EPA comments and will incorporate them into the document. EG&G does not agree with several of the CDPHE comments as detailed in the attachment.

This response reflects comments received from Rocky Flats Field Office by EG&G during review meetings held on September 15 and 19, 1994. Please direct any comments or questions to Win Chromec of Environmental Restoration Program Division/Risk Assessment. Win may be paged on 5144.

SG Stiger

S. G. Stiger, Director
Environmental Restoration
Program Division

FWC:kld

Orig. and 1 cc - J. M. Roberson

Attachments:
As Stated (2)

cc:
M. N. Silverman - DOE, RFFO
D. C. Moody - LANL
S. E. Wagner - LANL

Best Available Copy

ADMIN RECORD
SW-A-003764

RESPONSE TO COMMENTS ON THE PROGRAMMATIC RISK-BASED PRELIMINARY REMEDIATION GOALS

Responses to comments received from EPA and CDPHE on the **Programmatic Risk-Based Preliminary Remediation Goals** (July 1994) follow.

Response to EPA Comments

Comment 1. The recommended exposure parameters for inhalation rate (1.25 m^3/hr) and soil ingestion (480 mg/day) for a construction worker will be incorporated into the Programmatic Risk-Based Preliminary Remediation Goals (PRGs).

Comment 2. The PRG document was based on the 1993 HEAST report. All toxicity values will be compared to the latest IRIS quarterly update or the 1994 HEAST report.

Comment 3. The PRGs will be recalculated using the recommended exposure parameters for a construction worker and updated toxicity values. All PRG values will then go through QC to assure accuracy.

Response to CDPHE Comments

Comment 1. A meeting was held on May 24, 1994, in which the methodology for development of the PRGs was presented to CDPHE and EPA. Comments were received regarding the need for a dermal assessment if no further action was an option following application of the conservative screen. No other comments were received at that time. This meeting was the source of our comment in the document.

Comment 2. All references to the PRGs being protective of the environment will be removed from the document. Ecological action levels are currently being developed.

Comment 3. Juvenile exposure by soil ingestion is specified by EPA in RAGS, Part B (1991). This is the only juvenile exposure specified in EPA guidance for PRG development. EPA guidance was followed. DOE is not "ignoring risk to children" nor is it "cutting a corner." The PRGs are conservatively based and when used in conjunction with the CDPHE screen will identify areas of concern. Table 1 compares PRGs developed using the default equation with an age-adjusted ingestion factor (AAo), with only a childhood exposure, age 1-6 yrs (Child), and with both age-adjusted ingestion and inhalation factors (AAoi) for a selection of both carcinogenic and noncarcinogenic chemicals. Chromium VI represents the worst-case carcinogenic chemical, having only an inhalation slope factor (SF_i). Ratios of the alternative PRGs to the default (AAo/child and AAo/AAoi) are calculated for each chemical.. The differences are small. The inclusion of a childhood inhalation exposure will not significantly affect the conclusions of the conservative screen .

Comment 4. This comment pertains to the use of the PRGS in the CDPHE conservative screen and not the development of the PRGS. For the purpose of the CDPHE screen DOE will assess soil from 0-12 feet using the surface soil PRGs.

Comment 5. The PRGs are a screening level tool. Risk-based PRGs are typically limited to PCOCs having toxicity factors published in IRIS (EPA) or HEAST (EPA). The COC selection process has never incorporated chemicals without toxicity factors. Surrogate toxicity factors for other chemicals may be estimated as part of the Toxicity Assessment for the Baseline Risk Assessment.

Comment 6a. See EPA comment one.

Comment 6b. See EPA comment one.

Comment 6c. CDPHE apparently does not have the RAGS Part B update for radionuclides. The gamma exposure time factor is consistent with the latest guidance. See attachment.

Comment 6d. The gamma shielding factor (S_e) used was from the latest EPA guidance. Radionuclides at the RFETS have very low gamma energies and all are self-shielded by the soil. The default value is used appropriately for the PRGs.

Comment 6e. It is stated on page 34 of RAGS Part B that the volatilization factor is appropriate only for volatile radionuclides. None of the radionuclides assessed were judged to be volatile; defined by RAGS Part B as having "a Henry's Law constant of greater than 1×10^{-5} atm m^3/mole and a molecular weight of less than 200 g/mole."

Comment 6f. The Dinan, 1992, guidance is provided with this response to comments.

TABLE 1

	PRG	SFi	SFo	IF_i	IR	ED	BW
		CARCINOGENIC					
Cr VI[1]							
AAo[2]	9.62e+02	4.10e+01			20	30	70
Child	1.18e+03	4.10e+01			17.5	6	15
AAoi[3]	5.93e+02	4.10e+01		13.9			
AAo/child	8.1e-01						
AAo/AAoi	1.62						
Be							
AAo[2]	1.49e-01	8.40e+00	4.30e+00		20	30	70
Child	2.12e-01	8.40e+00	4.30e+00		17.5	6	15
AAoi[3]	1.49e-01	8.40e+00	4.30e+00	13.9			
AAo/child	7.0e-01						
AAo/AAoi	1.00						
		NONCARCINOGENIC					
		RfDi	RfDo	IF	IR	ED	BW
Ba							
AAo[2]	1.91e+04	1.43e-04	7.00e-02		20	30	70
Child	5.42e+03	1.43e-04	7.00e-02		17.5	6	15
AAoi[3]	1.90e+04	1.43e-04	7.00e-02	13.9			
AAo/child	3.5e+00						
AAo/AAoi	1.00						

1. Chromium VI (CrVI) does not have a SF for ingestion.
2. AAo is the default PRG equation with the age-adjusted ingestion factor.
3. AAoi includes an age-adjusted inhalation factor:

$IF_i = ((IR_{age\ 1\text{-}6} \times ED_{age\ 1\text{-}6})/BW_{age\ 1\text{-}6}) + ((IR_{age\ 7\text{-}31} \times ED_{age\ 7\text{-}31})/BW_{age\ 7\text{-}31}$

Where:	$IR_{age\ 1\text{-}6} = 17.5\ m^3/day$	$IR_{age\ 7\text{-}31} = 20\ m^3/day$
	$ED_{age\ 1\text{-}6} = 6$ yrs	$ED_{age\ 7\text{-}31} = 24$ yrs
	$BW_{age\ 1\text{-}6} = 15$ kg	$BW_{age\ 7\text{-}31} = 70$ kg

NOV 9 1992

Attachment 2
94-RF-09791

NOTE TO: Regional Toxic Integration Coordinators

FROM: Janine Dinan

SUBJECT: Changes to Equations in the Part B Guidance

Attached are updates to the soil-to-air volatilization and radiation equations presented in the Risk Assessment Guidance for Superfund, Human Health Evaluation Manual: Part B (December, 1991).

OERR asked the Air/Superfund contractor (Environmental Quality Management) to perform a limited validation study on the volatilization factor (VF) equation presented in Part B. As a result of that study, they felt it would be better to modify the equation to take into account the effect of soil moisture on the flux of chemicals through the soil. The original Hwang and Falco model used in Part B did not take in account the effect of soil moisture. The validation study showed, that for some of the more volatile and soluble compounds (Benzene, Toluene, Ethylbenzene and Xylenes), the Part B equation over-predicted emissions by a factor of 5 to 10. In addition, EQM suggested that we modify the soil saturation concentration (C_{sat}) equation to reflect the fraction of a chemical found in the vapor phase as well the fractions bound to the organic content of soil and dissolved in the soil moisture.

Since Part B was developed, the Office of Radiation Programs has changed the way it calculates slope factors for external exposures. As a result the units are different than the ones originally presented in Part B. To avoid confusion, we felt it was best to develop modified equations.

Although a more formal memo will be distributed to the Regions (and other users of Part B) with this information, I felt that you should have these changes in hand as soon as possible.

Soil-to-Air Volatilization Factor (VF)

The volatilization factor (VF) is used for defining the relationship between the concentration of contaminant in soil and the volatilized contaminant in air. This relationship was established as part of the Hwang and Falco (1986) model developed by EPA's Exposure Assessment Group in the Office of Research and Development. Hwang and Falco present a method intended primarily to estimate the permissible residual levels associated with the cleanup of contaminated soils.

The Hwang and Falco model was used as the basis for the VF equation presented in the Part B guidance. Since the time of Part B, OERR sponsored a study to validate the VF equation by comparing the modelled results with data from actual bench and pilot scale studies. The results of the validation study (EQM, 1992) suggested the need to modify the VF equation in Part B to take into account the decrease in the rate of flux due to the effect of soil moisture on effective diffusivity (D_{ei}). Thus, the D_{ei} equation for dry soil ($D_i \times E^{0.33}$) was replaced with an equation from Millington and Quirk (1961) where $D_{ei} = D_i\ (Pa^{3.33}/Pt^2)$.

$$VF\ (m^3/kg) = \frac{(LS \times V \times DH)}{A} \times \frac{(3.14 \times \alpha \times T)^{1/2}}{(3 \times D_{ei} \times P_a \times K_{as} \times 10^{-3}\ kg/mg)}$$

where:

$$\alpha = \frac{D_{ei} \times P_a}{P_a + (\rho_s)\ (1 - P_a)/K_{as}}$$

Parameter	Definition (units)	Default
VF	Volatilization factor (m^3/kg)	--
LS	Length of side of contaminated area (m)	45
V	Windspeed in mixing zone (m/s)	2.25
DH	Diffusion height (m)	2
A	Area of contamination (cm^2)	20,250,000
D_{ei}	Effective diffusivity (cm^2/s)	$D_i(Pa^{3.33}/Pt^2)$
P_a	Air filled soil porosity (unitless)	$P_t - \theta\beta$
P_t	Total soil porosity (unitless)	$1-(\beta/\rho_t)$

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θ	Soil moisture content (cm^3-water/g-soil)	10% or 0.1
β	Soil bulk density (g/cm^3)	1.5
ρ_s	True soil density or particle density (g/cm^3)	2.65
K_{as}	Soil-air partition coefficient (g-soil/cm^3-air)	$(H/K_d) \times 41$ (41 is a conversion factor)
T	Exposure interval (s)	7.9×10^8 s
D_i	Diffusivity in air (cm^2/s)	Chemical-specific
H	Henry's Law constant ($atm\text{-}m^3/mol$)	Chemical-specific
K_d	Soil-water partition coefficient (cm^3/kg)	$K_{oc} \times OC$
K_{oc}	Organic carbon partition coefficient (cm^3/kg)	Chemical-specific
OC	Organic carbon content of soil (fraction)	2% or 0.02

Soil Saturation Concentration (C_{sat})

The basic principle of the VF model is applicable only if the soil contaminant concentration is at or below saturation. Saturation is the soil contaminant concentration at which the adsorptive limits of the soil particles and the solubility limits of the available soil moisture have been reached. Above saturation, pure liquid-phase contaminant is expected in the soil. Under such conditions, the partial pressure of the pure contaminant and the partial pressure of the air in the interstitial pore spaces cannot be calculated without first knowing the mole fraction of the contaminant in the soil. Therefore, above saturation the PRG cannot be accurately calculated based on volatilization. Because of this limitation, the chemical concentration in soil (PRG) calculated using VF must be compared with the soil saturation concentration (C_{sat}). If the PRG calculated using VF is greater than C_{sat}, the PRG should be set equal to C_{sat}.

$$C_{sat} = \frac{(K_d \times C_w \times \beta) + (C_w \times P_w) + (C_w \times H' \times P_a)}{\beta}$$

Parameter	Definition (units)	Default
C_{sat}	Soil saturation concentration (mg/kg)	--
K_d	Soil-water partition coefficient (L/kg)	$K_{oc} \times OC$
K_{oc}	Organic carbon partition coefficient (L/kg)	Chemical-specific
OC	Organic carbon content of soil (fraction)	2% or 0.02
C_w	Upper limit of free moisture in soil (mg/L-water)	$S \times \theta_m$
θ_m	Soil moisture content (kg-water/kg-soil)	10% or 0.1
S	Solubility in water (mg/L-water)	Chemical-specific
β	Soil bulk density (kg/L)	1.5
P_w	Water filled soil porosity (unitless)	$P_t - P_a$
H'	Henry's Law constant (unitless)	H x 41, where 41 is a conversion factor
H	Henry's Law constant (atm-m³/mol)	Chemical-specific
P_a	Air-filled soil porosity (unitless)	$P_t - \theta\beta$
θ	Soil moisture content (L-water/kg soil)	10% or 0.1
P_t	Total soil porosity (unitless)	$1 - (\beta/\rho_s)$
ρ_s	True soil density or particle density (kg/L)	2.65

Please note that the equation presented here for C_{sat} is also a modification of the equation presented in the Part B guidance. This equation also takes into account the amount of contaminant that is in vapor phase in the pore spaces of the soil.

REVISIONS TO CHAPTER 4
RISK-BASED PRGs FOR RADIOACTIVE CONTAMINANTS

(1) **Change in the Default Value for T_e Under the Commercial/Industrial Soil Scenario.** The default value for the gamma exposure time factor, T_e, for workers, discussed in Section 4.1.2 and used in Equation (13) under the commercial/industrial soil exposure scenario, has been changed from 1 to 0.3. T_e is the ratio of the number of hours an individual is exposed to an external gamma radiation source during a 24-hr day. For workers, the exposure time is assumed to be 8 hours each day, resulting in a T_e value of 0.3 (i.e., 8/24). For residential populations, the exposure time is assumed to be 24 hours per day, with $T_e = 24/24 = 1$. Note that the default value for T_e for the residential soil scenario has not been changed.

(2) **Revision of the Default Values for SF_i for Ra-226/Rn-222 and Ra-224/Rn-220.** [See Exhibit 3 attached.] The inhalation slope factor values listed for Rn-222+D and Rn-220+D in the box on page 40 have been replaced with the most current values taken from *HEAST* 1992 Table 4a. In addition, the discussions in the footnotes have been rewritten to provide better clarity.

(3) **Revision of Equations (11) and (11').** [See Exhibit 1 attached.] Equation (11) on page 37, which is used to calculate the risk-based radionuclide soil concentration, RS_r for residential soils, has been revised to accept the new external exposure slope factors given in Table 4a of HEAST 1992. The "old" external slope factors were calculated assuming that individual gamma-emitting radionuclides were uniformly distributed over an infinite surface area with no depth, and were expressed in units of risk/year per pCi/m² of soil. In the original Equation (11), assumptions had to be made for the depth of radionuclides in soil, D, and the soil density, SD. Since the "new" external exposure slope factors account for soil depth and density (and are expressed in correct units of risk/year per pCi/g soil), the terms D and SD have been dropped from the revised Equation (11). Revised Equation (11') in Exhibit 1 is the reduced form of revised Equation (11).

(4) **Revision of Equations (13) and (13') and Addition of Equation (13'').** [See Exhibit 2 attached.] Similar to the revision of Equation (11) discussed above, Equation (13) on page 39, has also been revised to accept the new external exposure slope factors in Table 4a of HEAST 1992. The terms D and SD have been dropped from the revised Equation (13). Revised Equation (13') in Exhibit 2 - for use in calculations involving volatile radionuclides - is the reduced form of revised Equation (13). Reduced Equation (13") has been added for use in calculations involving non-volatile radionuclides, and differs from Equation (13') by dropping the soil-to-gas volatilization factor (VF) from the calculations.

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Exhibit 1. Revised Equations for Calculating Radionuclide PRGs — Residential Soil

RADIONUCLIDE PRGs: RESIDENTIAL SOIL — CARCINOGENIC EFFECTS

Total risk = $RS \times [(SF_o \times 10^{-3} g/mg \times EF \times IF_{soil/adj}) + (SF_e \times ED \times (1-S_e) \times T_e)]$

RS (pCi/g; risk-based) = $\dfrac{TR}{(SF_o \times 10^{-3} g/mg \times EF \times IF_{soil/adj}) + (SF_e \times ED \times (1-S_e) \times T_e)}$ (11)

where:

Parameters	Definition (units)	Default Value
RS	radionuclide PRG in soil (pCi/g)	—
TR	target excess individual lifetime cancer risk (unitless)	10^{-6}
SF_o	oral (ingestion) slope factor (risk/pCi)	radionuclide-specific
SF_e	external exposure slope factor (risk/yr per pCi/g)	radionuclide-specific
EF	exposure frequency (days/yr)	350 days/yr
ED	exposure duration (yr)	30 yr
$IF_{soil/adj}$	age-adjusted soil ingestion factor (mg-yr/day)	3600 mg-yr/day (see Equation (12))
S_e	gamma shielding factor (unitless)	0.2 (see Section 4.1.2)
T_e	gamma exposure time factor (unitless)	1 (see Section 4.1.2)

REDUCED EQUATION FOR RADIONUCLIDE PRGs:
RESIDENTIAL SOIL — CARCINOGENIC EFFECTS

Risk-based PRG (pCi/g; TR = 10^{-6}) = $\dfrac{1 \times 10^{-6}}{1.3 \times 10^{-3} (SF_o) + 24(SF_e)}$ (12)

where:

SF_o = radionuclide-specific oral (ingestion) slope factor (risk/pCi)
SF_e = radionuclide-specific external exposure slope factor (risk/yr per pCi/g)

10 12

Exhibit 2. Revised Equations for Calculating Radionuclide PRGs — Commercial/Industrial Soil.

RADIONUCLIDE PRGs: COMMERCIAL/INDUSTRIAL SOIL — CARCINOGENIC EFFECTS*

$$\text{Total risk} = RS \times ED \times [(SF_o \times 10^{-3} g/mg \times EF \times \overset{IR}{IF_{soil}}) + (SF_i \times 10^3 g/kg \times EF \times IR_{air} \times 1/VF) + (SF_i \times 10^3 g/kg \times EF \times IR_{air} \times 1/PEF) + (SF_e \times (1-S_e) \times T_e)]$$

$$\text{RS (pCi/g; risk-based)} = \frac{TR}{ED \times [(SF_o \times 10^{-3} g/mg \times EF \times \underset{IR}{IF_{soil}}) + ((SF_i \times 10^3 g/kg \times EF \times IR_{air}) \times (1/VF + 1/PEF)) + (SF_e \times (1-S_e) \times T_e)]} \quad (13)$$

where:

Parameters	Definition (units)	Default Value
RS	radionuclide PRG in soil (pCi/g)	–
TR	target excess individual lifetime cancer risk (unitless)	10^{-6}
SF_o	oral (ingestion) slope factor (risk/pCi)	radionuclide-specific
SF_e	external exposure slope factor (risk/yr per pCi/g)	radionuclide-specific
EF	exposure frequency (days/yr)	250 days/yr
ED	exposure duration (yr)	25 yr
IR_{air}	workday inhalation rate of air (m^3/day)	20 m^3/day
IR_{soil}	daily soil ingestion rate (mg/day)	50 mg/day
VF	soil-to-air volatilization factor (m^3/kg)	radionuclide-specific (see Section 4.2.3)
PEF	particulate emission factor (m^3/kg)	4.63×10^9 m^3/kg (see Section 3.3.2)
S_e	gamma shielding factor (unitless)	0.2 (see Section 4.1.2)
T_e	gamma exposure time factor (unitless)	0.3 (see Section 4.1.2)
SF_i	inhalation	

NOTE: Most radionuclides are not volatile under normal ambient conditions. For these radionuclides, the soil-to-air volatilization exposure pathway may be omitted from risk-based calculations (see Section 4.2.3).

REDUCED EQUATION FOR RADIONUCLIDE PRGs: COMMERCIAL/INDUSTRIAL SOIL — CARCINOGENIC EFFECTS*

(a) Reduced equation for volatile radionuclides:

$$\text{Risk-based PRG (pCi/g; TR} = 10^{-6}) = \frac{1 \times 10^{-6}}{3.1 \times 10^2 (SF_o) + (1.3 \times 10^8/VF + 2.7 \times 10^{-2})(SF_i) + 6(SF_e)} \quad (13')$$

(b) Reduced equation for non-volatile radionuclides:

$$\text{Risk-based PRG (pCi/g; TR} = 10^{-6}) = \frac{1 \times 10^{-6}}{3.1 \times 10^2 (SF_o) + 2.7 \times 10^{-2} (SF_i) + 6(SF_e)} \quad (13'')$$

where:

SF_o	=	radionuclide-specific oral (ingestion) slope factor (risk/pCi)
SF_i	=	radionuclide-specific ~~oral (ingestion)~~ inhalation slope factor (risk/pCi)
SF_e	=	radionuclide-specific external exposure slope factor (risk/yr per pCi/g)
VF	=	radionuclide-specific soil-to-air volatilization factor (m^3/kg) (see Section 4.2.3)

* NOTE: See Section 4.2.3 when calculating PRGs for Ra-226/Rn-222 and Ra-224/Rn-220.

Exhibit 3. Revised Soil Default Values for SF_i for Ra-226/Rn-222 and Ra-224/Rn-220

Soil Default Values for VF and SF_i for Ra-226/Rn-222 and Ra-224/Rn-220

Radium	Default VF Value* (pCi/kg Ra per pCi/m³ Rn)	Inhalation Slope Factor, SF_i (risk/pCi)**
Ra-226	8	7.7E-12
Ra-224	200	5.0E-11

* The default VF value of 8 for Ra-226 was calculated as the ratio of the average natural background concentration of Ra-226 in soil (1,000 pCi/kg) to the corresponding average natural background concentration of Rn-222 in air (120 pCi/m³). Similarly, the default VF value of 200 for Ra-224 was calculated as the ratio of the average Ra-224 background concentration in soil (1,000 pCi/g) to the average Rn-220 background concentration in air (5 pCi/m³). Natural background levels for radium and radon were taken from NCRP 1976 and UNSCEAR 1982.

** Inhalation slope factor values are for Rn-222 plus decay products (i.e., Rn-222+D) formed from the radioactive decay of Ra-226, and for Rn-220+D from the decay of Ra-224. SF values were taken from Table 4a of EPA's Health Effects Assessment Summary Tables (HEAST 1992).